

REDUCING HOSPITAL OUTPATIENT WAITING TIME USING LEAN SIX SIGMA: A SYSTEMATIC REVIEW

Reduksi Waktu Tunggu Rawat Jalan di Rumah Sakit dengan Lean Six Sigma: Systematic Review

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Abstract

Background: Lean Six Sigma (LSS) is a beneficial data-driven tool for quality improvement. Literature regarding the use of LSS to reduce hospital outpatient waiting time is scarce despite numerous problems encountered in many countries.

Aims: This systematic review aims to evaluate the causes of long outpatient waiting time, demonstrate the effectiveness of LSS and the improvement strategies applied to reduce outpatient waiting time.

Methods: Literature search was performed on eight databases: Proquest, Wiley, Science Direct, Taylor and Francis, Oxford Journal, Sage Publication, Scopus, and Pubmed. Inclusion criteria were peer-reviewed English articles published from January 1, 2003, to May 25, 2021, and studies conducted in hospital settings.

Results: Nine relevant articles were included. Inefficient clinic processes, inappropriate scheduling, human resources problems, workplace factors, patient communication problems, and patient characteristics are root causes found for long outpatient waiting time. All studies revealed a reduction in outpatient waiting time (5.2% to 97%) after implementation of LSS. Process redesign, improvement in appointment scheduling, patient communication, and improvement in workplace design, were strategies used to reduce outpatient waiting time. These strategies increase the number of patients seen and hospital gross revenue, as well as patient satisfaction.

Conclusion: LSS is beneficial to reduce outpatient waiting time. Process redesign provide advantageous results.

Keywords: hospital, lean six sigma, outpatient waiting time, process redesign

Abstrak

Latar Belakang: Lean Six Sigma (LSS) merupakan tool berbasis data yang bermanfaat untuk meningkatkan mutu layanan. Literatur tentang manfaat LSS dalam mereduksi waktu tunggu rawat jalan rumah sakit masih sedikit meskipun permasalahan ini sering dijumpai.

Tujuan: Penelitian ini bertujuan untuk mengevaluasi penyebab waktu tunggu rawat jalan yang lama, memperlihatkan efektivitas LSS dan strategi perbaikan untuk mereduksi waktu tunggu.

Metode: Penelusuran literatur dilakukan pada delapan database: Proquest, Wiley, Science Direct, Taylor and Francis, Oxford Journal, Sage Publication, Scopus, dan Pubmed. Kriteria inklusi meliputi artikel berbahasa Inggris yang dilakukan peer-review, dipublikasikan antara 1 Januari 2003 sampai 25 Mei 2021, dan studi yang dilakukan di rumah sakit.

Hasil: Sejumlah sembilan artikel memenuhi kriteria. Proses yang tidak efisien, penjadwalan yang tidak tepat, permasalahan sumber daya manusia, faktor tempat kerja, permasalahan komunikasi pasien, dan karakteristik pasien merupakan penyebab waktu tunggu yang lama. Semua penelitian menunjukkan penurunan waktu tunggu rawat jalan (5,2 sampai 97%) setelah implementasi LSS. Redesain proses melalui perbaikan penjadwalan perjanjian, komunikasi pasien, dan perbaikan desain tempat kerja merupakan strategi untuk mereduksi waktu tunggu rawat jalan yang akhirnya meningkatkan jumlah pasien dan pendapatan rumah sakit, serta kepuasan pasien.

Kesimpulan: LSS bermanfaat dalam mengurangi waktu tunggu pasien. Redesain proses memberikan manfaat yang menguntungkan.

Kata kunci: rumah sakit, lean six sigma, waktu tunggu rawat jalan, redesign proses



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Introduction

Lean Six Sigma (LSS) methodology has been widely used for quality improvement processes. This methodology was initially used in manufacturing and supply chain processes, but in practice, it can be used in many aspects of the business (Bhaskar, 2020). The use of LSS methodology in healthcare was pioneered by Stanford Hospital and Clinics in 2003 (Verver *et al.*, 2006). In LSS, the lean thinking concept focusing on value stream and waste elimination is combined with that of Six Sigma, focusing on variation reduction and customer satisfaction, resulting in a powerful data-driven tool to solve problems and eventually reduce costs (Bevan *et al.*, 2005; Ninerola, Sánchez-Rebull and Hernández-Lara, 2020).

Adoption of the LSS methodology in healthcare is beneficial for improving clinical indicators and waiting time, reducing errors, cutting costs, increasing productivity, and optimizing human resources (Honda *et al.*, 2018; Zimmermann, Siqueira and Bohomol, 2020). LSS has been implemented in numerous healthcare settings, such as surgery, general health, imaging and radiology, administrative and operations, obstetrics and gynecology, and emergency and traumatology (Honda *et al.*, 2018), but the literature regarding the use of waiting time reduction strategies in an outpatient clinic setting remains limited. This is contradictory to the problem of long waiting times in hospital outpatient departments, which to this day still presents a challenge in most countries (Naiker *et al.*, 2018). Until recently, no systematic review had been performed to demonstrate the effectiveness of the LSS methodology i.e. reducing waiting time in hospital outpatient settings. This study aims to fill this gap and demonstrate strategies for improvement using the LSS methodology.

Method

Search Strategy

The search strategy for this review is in line with The PRISMA flow diagram from the PRISMA 2020 statement (Page *et al.*, 2021). The eight databases used for the literature search were Proquest, Wiley, Science Direct, Taylor and Francis, Oxford Journal, Sage Publication, Scopus, and PubMed, with May 25, 2021, being the date last searched. The search terms included “lean six sigma,” “outpatient waiting time,” and “hospital.” The research question was “How effective was the LSS methodology in reducing hospital outpatient waiting time and what improvement strategies were implemented to obtain waiting time reduction?” The research question was formulated on the basis of the PICOS strategy (Table 1).

Table 1. PICOS Formulation

Population (P)	Outpatient
Intervention(I)	Lean Six Sigma (LSS) methodology
Comparison (C)	(-)
Outcome (O)	1. Waiting time reduction due to implementation of LSS methodology 2. Improvement strategies implemented to obtain waiting time reduction
Study (S)	All types of hospital-based study

Study Selection

Studies were eligible for inclusion if they were peer-reviewed English articles, with no limitation on countries, a primary research studies, published from January 1, 2003, to May 25, 2021, and were conducted in hospital settings. Quantitative and mixed method studies were included as long as waiting time before and after the intervention was measured. Studies were excluded if they were opting for lean methodology or Six Sigma methodology exclusively, and not the integration of lean and Six Sigma. Studies based on simulations or models with no actual implementation studies regarding referral waiting times and qualitative studies were also excluded.

Article Screening and Data Extraction

A literature search was performed on eight databases using the specified search terms and uploaded to the Mendeley Reference Manager to check for duplicates. Duplicates were removed, and articles were screened for titles and abstracts. Abstracts that fulfilled the criteria were then screened for full text. References of the literature retrieved were also screened to capture relevant articles, which were then classified as studies via other methods in the PRISMA Flow Diagram. Literature search, titles, abstract screening, data extraction, as well as quality assessment were conducted by EW and RA, with guidance from AA. The differences between the authors were resolved by discussion.

Risk of Bias

The risk of bias was assessed using The Risk of Bias in Non-randomized Studies – Interventions (ROBINS-I) assessment tool from the Cochrane Library (Sterne *et al.*, 2016). Studies were based on seven domains of bias and judged into five

criteria, i.e. low risk of bias, moderate risk of bias, serious risk of bias, critical risk of bias, and no information. Only one study (Kam *et al.*, 2021) showed a low risk of bias, while three other studies (Bhat and Jnanesh, 2014; Gijo and Antony, 2014; Al-Zain *et al.*, 2019) had a moderate risk of bias, and the other five studies (Lin *et al.*, 2013; Dubey *et al.*, 2016; Jayasinha, 2016; Gavriloff, Ostrowski-Delahanty and Oldfield, 2017; Ciulla *et al.*, 2018) had a serious risk of bias (Table 2). Most studies had a serious risk of confounding bias owing to the nature of non-randomized studies.

Result and Discussion

As many as 367 articles were identified via a database search, with 27 duplicates removed. Identification using other methods resulted in six articles. After screening titles, abstracts, and full-text articles, nine articles were included in this review (Figure 1).

Table 2. Risk of bias of included studies

No.	Study	Types of Bias							Overall Risk of Bias
		D1	D2	D3	D4	D5	D6	D7	
1.	Kam, et al.	1	1	1	1	1	1	1	1
2.	Al-Zain, et al.	1	2	2	2	1	2	1	2
3.	Ciulla, et al.	3	1	1	1	2	1	1	3
4.	Gavriloff, et al.	3	1	1	1	0	1	1	3
5.	Dubey, et al.	3	0	1	1	1	1	0	3
6.	Jayasinha Y	3	0	1	1	1	1	0	3
7.	Bhat, et al.	2	1	1	1	1	2	1	2
8.	Gijo, et al.	2	1	1	1	1	0	1	2
9.	Lin, et al.	3	2	1	1	1	1	1	3

*D: Domain; D1, confounding; D2, selection of participants; D3, classification of intervention; D4, deviation from intended interventions; D5, missing outcome data; D6, measurement of outcomes; D7, selection of reported results. Risk of bias assessment: 0-No information; 1-Low; 2-Moderate; 3-Serious; 4-Critical.

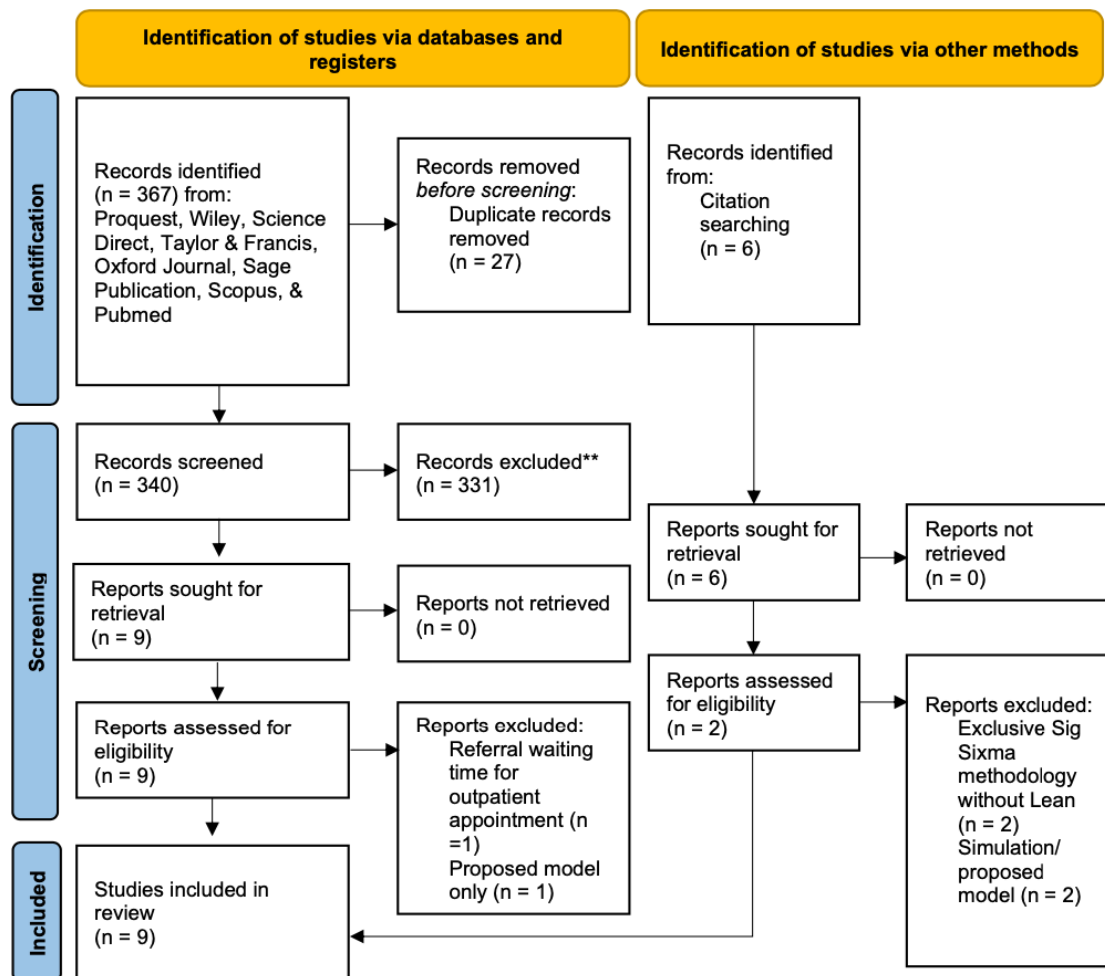


Figure 1. PRISMA flow diagram of included studies

Root Causes for Long Waiting Time

Six domains were identified as the root causes for long outpatient waiting times: inefficiency of clinic processes, inappropriate scheduling, human resource problems, workplace factors, patient communication problems, and patient characteristics. Almost all studies (Lin *et al.*, 2013; Bhat and Jnanesh, 2014; Gijo and Antony, 2014; Dubey *et al.*, 2016; Jayasinha, 2016; Ciulla *et al.*, 2018; Kam *et al.*, 2021) have shown that inefficiency of clinical processes is the root cause of an imbalance between supply and demand. Inappropriate scheduling is the second most frequent root cause, including scheduling patients during peak clinic hours (Lin *et al.*, 2013; Gijo and Antony, 2014; Dubey *et al.*, 2016; Gavriloff, Ostrowski-Delahanty and Oldfield, 2017; Kam *et al.*, 2021) and overbooking appointments (Al-Zain *et al.*,

2019). Human resource problems were the third most frequent root cause of the long outpatient waiting times. Three studies (Lin *et al.*, 2013; Gijo and Antony, 2014; Al-Zain *et al.*, 2019) showed doctors as the main problem, including doctors' unscheduled breaks (Al-Zain *et al.*, 2019), late doctor attendance (Gijo and Antony, 2014; Al-Zain *et al.*, 2019), doctors' addition to a clinic at an already crowded time (Lin *et al.*, 2013), and illegible prescriptions (Gijo and Antony, 2014). Workplace factors were another contributor to long outpatient waiting times. Two studies (Bhat and Jnanesh, 2014; Gijo and Antony, 2014) showed that the unavailability of stationaries, non-ergonomic workplaces, lack of visual management, and misplacement of records were issues related to workplace problems.

Patient communication problems were encountered as one of the root cause in two studies. Lack of signage (Al-Zain *et al.*, 2019), lack of information regarding the referral system and insurance issues, and lack of information about construction sites within the hospital (Lin *et al.*, 2013) were described as the root causes. Patient characteristics and preferences also played a role in long outpatient waiting times. Three studies

demonstrated that patient age (Ciulla *et al.*, 2018), patients who did not provide correct information (Bhat and Jnanesh, 2014), and patients' personal preferences toward certain doctors (Gijo and Antony, 2014) were issues. The characteristics of the included studies are presented in Table 3. The overall reduction in average waiting time of the ninth study in Table 3 is shown in Figure 2.

Table 3. Characteristics of included studies

No	Study Title & Year of Publication	Sample Size (pre & post intervention)	Sampling	Main Outcomes	Improvement Strategies
1	Using Lean Six Sigma Techniques to Improve Efficiency in Outpatient Ophthalmology Clinics (Kam <i>et al.</i> , 2021)	2241 & 3490	Total sampling: Two five-months audit	9% increase in number of patients seen per session, significant reduction in duration (median 131 min to 107 minutes) & variability of patient in-clinic time [133 min (84-217 min to 91 min (71-162 min)].	Moving the start time of screening staff & patients appointment, revising appointment slot time lengths, creating dedicated emergency & inpatient appointment placeholders, providing registrar with 'live' scheduling app, dedicating post-operative clinic.
2	Implementing Lean Six Sigma in a Kuwaiti Private Hospital (Al-Zain <i>et al.</i> , 2019)	168 & 156	Sampling on patient's visits over 8-working days	Sigma level & waiting time improved for appointments & walk-ins on Saturdays (300% and 67% respectively), as well as for appointments and walk-ins on weekdays (288% and 55% respectively). Cost benefit analysis showed improvement in savings.	Arranging doctors schedules (surgeries, breaktimes, average service time), preparing patient's files before start time of clinic, informing patients if doctor was absent & offering to see different doctor, arranging appointments only by receptionists, dedicating receptionist to accommodate insurance patients, installing clear signage above Q-matic machine, applying checklist & recommendation to monitor system.

No	Study Title & Year of Publication	Sample Size (pre & post intervention)	Sampling	Main Outcomes	Improvement Strategies
3	Lean Six Sigma Techniques to Improve Ophthalmology Clinic Efficiency (Ciulla <i>et al.</i> , 2018)	2078 & 1071	Total sampling: 3 months pre- & 1.5 months post-implementation	Decline in mean patient flow time by 18% & inpatient flow time SD by 4.6%. Patient and employee satisfaction scores improved.	Hiring additional technician, providing dedicated & parallel pathway for patients scheduled to receive injections with additional staff, examination rooms, and optical coherence tomography unit, redesigning scheduling protocol with consideration of patient flow time, room availability, patient's age & appointment time.
4	The Impact of Lean Six Sigma Methodology on Patient Scheduling (Gavriloff, Ostrowski-Delahanty and Oldfield, 2017)	3385 & 3738	Total sampling: 2-month-data for before & after implementation	More patients were treated after implementation of level-loading scheduling, which increase gross revenue. Reduce in average length of time (96 min to 91 min) ($p < 0.01$).	Applying level-loading scheduling with no more than 4 patients arrived at the same time
5	Using Lean Six Sigma to Improve Throughput Efficiency at Tertiary Care Eye Hospital (Dubey <i>et al.</i> , 2016)	No info	No info	19% reduction in median lead time (118 min to 95 min).	Removing unnecessary & repeated steps, placing file holders in ward & registration area using the first-in-first-out system, dedicating one registration counter for appointment, placing one councilor to reduce patients' motion, providing color maps of key areas in hospital for patients.
6	Decreasing Turnaround Time and Increasing Patient Satisfaction in a Safety Net Hospital-Based Pediatrics Clinic Using Lean Six	94 (pre)	No info	Decreased overall cycle time (113 to 90 min), improved patient's satisfaction (87% to 95%).	Changing the location of patient's financial workers to the front of the clinic, involving clerk during the process, implementing "MD Dispo" system, i.e. patients who did not

No	Study Title & Year of Publication	Sample Size (pre & post intervention)	Sampling	Main Outcomes	Improvement Strategies
	Sigma Methodologies (Jayasinha, 2016)				need orders or follow up appointments directly discharged by physician, co-locating patient care teams.
7	Application of Lean Six Sigma Methodology to reduce the cycle time of outpatient department service in a rural hospital (Bhat and Jnanesh, 2014)	56 (post)	Random sampling: 3 consecutive days	Decrease cycle time (4.27 min to 1.5 min), 97% reduction in average waiting time (32 min to 1 min), 91% decrease in queue length (from 11 patients to 1 patient).	Training selected supporting staff, marking location of stationary, arranging stationary closer to staff, placing single card 'kanban system' for misplacement of records, implementing queue maker to provide first-come-first-serve service, submitting patient's identity proof for new registration, using stickers for each rack of medical records shelf, keeping medical records shelf closer to the staff, relocating position of computer to meet ergonomic design.
8	Reducing Patient Waiting Time in Outpatient Department Using Lean Six Sigma Methodology (Gijo and Antony, 2014)	200 & 180	Stratification sampling	Average waiting time reduced from 57 min \pm 31.15 min to 24.5 min \pm 9.27 min.	Allocating junior doctors when there was huge crowd or requirement of more consulting time, listing the required stationary, re-planning doctor's schedule, providing software for entering all personal details of patients & the linked family, providing software for prescription and real-time update of medicine stock, and printing the prescription

No	Study Title & Year of Publication	Sample Size (pre & post intervention)	Sampling	Main Outcomes	Improvement Strategies
9	Use of Lean Sigma Principles in a Tertiary Care Otolaryngology Clinic to Improve Efficiency (Lin <i>et al.</i> , 2013)	188 & 141	No info: Sampling on patient visits over 5 days	12.2% decrease in lead time, 34% improvement in on-time starts for patients exams, and 34% reduction in motion per visit.	Creating reminder for patient to bring referral, educating staff about insurance verification process, revising appointment letter, improving signage, re-aligning registration staff schedule to accommodate peak times, re-examining all forms, creating centralized clinic calendar to identify times for making up clinics, adding-on patients only at off-peak times of the day, decentralizing vital signs measurement to exam rooms.

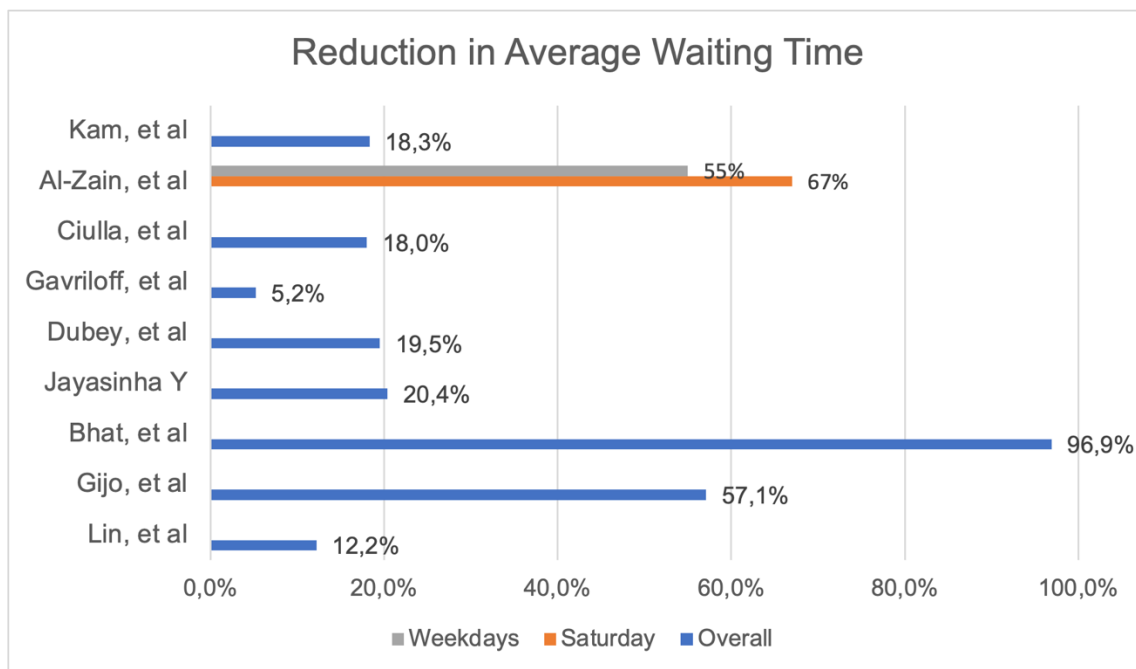


Figure 2. Reduction in average waiting time.

Waiting Time Reduction

All studies revealed a reduction in outpatient waiting time after implementation of the Lean Six Sigma (LSS) methodology, with a reduction varying from 5.2% to 97%. A reduction was found in the variability of patient in-clinic-time (Kam *et al.*, 2021), clinic cycle time (Bhat and Jnanesh, 2014; Jayasinha, 2016), queue length (Bhat and Jnanesh, 2014), and lead time (Lin *et al.*, 2013; Dubey *et al.*, 2016). A reduction in waiting time occurs not only in appointment patients but also in walk-in patients (Al-Zain *et al.*, 2019). The impact of the reduction in outpatient waiting time was an increase in the number of patients seen per session (Gavriloff, Ostrowski-Delahanty and Oldfield, 2017; Kam *et al.*, 2021) and well as an increase in gross revenue (Gavriloff, Ostrowski-Delahanty and Oldfield, 2017). A cost-benefit analysis showed an improvement in savings after the implementation of the LSS methodology (Al-Zain *et al.*, 2019). An increase in patient satisfaction has also been reported (Jayasinha, 2016; Ciulla *et al.*, 2018).

Improvement Strategies

Several improvement strategies have been proposed to deal with the inefficiency of clinical processes, which result in an imbalance between supply and demand. Those strategies include moving the screening process and appointment time earlier in the day (Kam *et al.*, 2021), providing dedicated clinic dealing with specialized care (for example, post-operative clinic (Kam *et al.*, 2021) and injection clinic (Ciulla *et al.*, 2018)), adding technician staff for dedicated clinic (Ciulla *et al.*, 2018), mobilizing junior doctors for crowded clinics (Gijo and Antony, 2014), decentralizing vital signs assessment (Lin *et al.*, 2013), providing patient's records before the starting time of the clinic (Al-Zain *et al.*, 2019), eliminating unnecessary processes or steps in the clinic, such as rechecking patients after being seen by the physician, and unnecessary forms (Lin *et al.*, 2013), implementing queue marker to provide first-come-first-serve service (Bhat and Jnanesh, 2014), changing the

location of the patient financial worker to the front of the clinic (Jayasinha, 2016), assigning one councilor as an informant to reduce patient's motion (Dubey *et al.*, 2016), training of selected supporting staff (Bhat and Jnanesh, 2014), and replanning doctor's schedule (Gijo and Antony, 2014).

Strategies implemented to resolve problems related to inappropriate scheduling include revising appointment slot time lengths (Kam *et al.*, 2021), creating dedicated appointment staff and counters (Dubey *et al.*, 2016; Kam *et al.*, 2021), using technology to provide 'live' scheduling application, arranging registration only by registration staff, dedicating staff to deal with insurance patients, redesigning scheduling protocols to align with patients' flow time, room availability, patient's age, and appointment time (Ciulla *et al.*, 2018), implementing level-loading scheduling (Gavriloff, Ostrowski-Delahanty and Oldfield, 2017), providing a registration area for first-in-first-out system, and limiting adding-on patients to off-peak times of the day (Lin *et al.*, 2013).

Doctors' schedules (surgeries, break times, and service time) (Al-Zain *et al.*, 2019) and providing e-prescribing software to deal with illegible prescriptions, and real-time updates of medicine stock (Gijo and Antony, 2014) were performed to address the issue of human resources factors. Improving patient communication may be beneficial in reducing outpatient waiting times. Installing clear signage for information (Lin *et al.*, 2013; Al-Zain *et al.*, 2019), providing information through reminders before the arrival of patients, and providing hospital color maps to explain key areas in the hospital were helpful measures to reduce outpatient waiting times. Accurate patient information was crucial to ensure this, requiring patients to submit identity proof (Bhat and Jnanesh, 2014) and using software providing linked patients' personal information (Gijo and Antony, 2014) were implemented. The 5S (sort, store, shine, standardize, and sustain) principles of the lean methodology are well-known for improving workplace efficiency. The strategies used were marking the location

of stationary, as well as relocating computers and patient records closer to the staff's location to meet the ergonomic position (Bhat and Jnanesh, 2014).

Discussion

Translation of the LSS methodology from the industrial to the healthcare sector is getting more in favor, as evident by a growing body of literature dealing with this issue. Nevertheless, the literature focusing on the integration of the Lean and Six Sigma methodologies remains limited. Only 15% of the entire body of literature, as compared to 66% of the lean methodology and 19% of the six methodologies, addressed the LSS methodology (Peimbert-garcía *et al.*, 2020). This is in line with our search, which resulted in only nine studies regarding waiting time in an outpatient setting over the last 18 years. Although lean literature is enormous in number, research on lean mostly focuses on small issues in the system rather than the system itself as a whole (Henrique and Godinho Filho, 2020), therefore a literature search on the LSS methodology could not include lean literature as well as Six Sigma literature that stood by itself.

The implementation of LSS in healthcare is mostly used for time and efficiency improvements, as these areas are associated with the improvement of processes (Peimbert-garcía *et al.*, 2020). The studies included in this review were also associated with improvements in time and efficiency. All the studies revealed a reduction in outpatient waiting time (from 5.2 to 97%) after implementation of LSS methodology in various kinds of clinics, either in a low risk of bias study or in a serious risk of bias study. A reduction in outpatient waiting time is beneficial for both health care institutions and patients. More patients can be served with the same resources at the same time. Cost-benefit analysis demonstrated an improvement in savings (Gavriloff, Ostrowski-Delahanty and Oldfield, 2017; Al-Zain *et al.*, 2019). For patients, a reduction in outpatient waiting time means faster diagnostic and therapeutic intervention, leading to improved patient

safety and satisfaction (Jayasinha, 2016; Ciulla *et al.*, 2018; Hu *et al.*, 2019).

The outpatient department is considered to provide complex ambulatory care. Issues regarding outpatient waiting times still present a challenge in most countries (Osundina and Opeke, 2017; Tlapa *et al.*, 2019). The root cause of the long outpatient waiting time mentioned in all the studies in this review was inefficient clinical processes. It is logical to assume that when demand exceeds supply, increasing supply by adding human resources would be beneficial in resolving the problem. However, studies in this review demonstrated that analyzing, rearranging, and realigning inefficient processes in outpatient systems could yield advantageous results (Lin *et al.*, 2013; Dubey *et al.*, 2016; Gavriloff, Ostrowski-Delahanty and Oldfield, 2017; Ciulla *et al.*, 2018; Al-Zain *et al.*, 2019; Kam *et al.*, 2021). The proposed process redesign is used to disentangle the bottleneck process. The study by Naiker *et al.* (Naiker *et al.*, 2018) which addressed issues of reducing outpatient referral waiting time, also mentioned that resource alignment, operational efficiency, and process improvement were important strategies to reduce referral waiting time. In addition to redesigning the healthcare process itself, patient communication is another factor that needs to be considered. Improving patient knowledge by providing more information would be helpful in reducing outpatient waiting times.

Successful application of the LSS methodology depends on several factors, including focusing project selection on key business priorities, aligning the project with strategic initiatives, sharing vision regarding what the organization will look after the implementation of LSS, and getting top management support through leadership (Furterer, 2014). Despite several studies showing successful LSS implementation in healthcare, some studies also showed the challenges and barriers that hinder the success of LSS initiatives. There have been fewer reports addressing challenges and barriers. Our search did not reveal any literature

showing negative findings of LSS implementation in the outpatient department setting. These results demonstrate that LSS is a powerful methodology for reducing waiting time, but might also be due to the bias of journals publishing positive results only (Peimbert-garcía *et al.*, 2020). Challenges in the successful implementation of LSS are categorized into four groups: management, preparation, people, and projects. The strongest preventive factor is resistance to cultural changes, especially by physicians and clinicians (Peimbert-garcía *et al.*, 2020). How to create a culture of continuous improvement and how to sustain the improvements implemented are issues that need further study (Henrique and Godinho Filho, 2020).

This review is limited to English publications only; therefore, unpublished literature or literature published in other languages might not be covered by this review. Most studies included in this review had confounding bias owing to the nature of non-randomized studies, which might have impacted the results.

Conclusion

LSS methodology has been beneficial in reducing outpatient waiting time. Improvement should be based on root cause analysis to yield a significant impact at the organizational level. The root causes found in most of the studies were inefficient clinical processes, in addition to inappropriate scheduling, human resource problems, workplace factors, patient communication problems, and patient characteristics. Process redesign through LSS methodology might provide advantageous results, reducing outpatient waiting time and improving hospital gross revenue.

Abbreviations

LSS: Lean Six Sigma; PICOS: Population, Intervention, Comparison, Outcome, Study; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; ROBIN-I: Risk of Bias in Non-randomized Studies.

Declarations

Ethics Approval and Consent Participant

Not applicable.

Conflict of Interest

The authors declare that there is no conflict of interest in this study.

Availability of Data and Materials

Data and materials can be provided upon request.

Authors' Contribution

Literature search, title and abstract screening, data extraction, and quality assessment were conducted by EW and RA, with guidance from AA. AA reviewed all the manuscript.

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